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No effect of focused attention whilst eating on later snack food intake: Two laboratory experiments

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ABSTRACT

Focusing attention on food during a meal has been shown to reduce later snack consumption. We report the results of two studies that aimed to replicate this effect and to elucidate the underlying mechanisms. We hypothesised that focused attention during a lunchtime meal would improve visual memory and/or memory for the satiating effects of the meal, and that this would reduce later food intake. In Study 1, participants ($N = 108$, 52.8% female, BMI $M = 25.75\ kg/m^2$) were randomly allocated to eat a fixed lunchtime meal while listening to instructions that encouraged them to pay attention to the sensory properties of the meal (focused attention condition), or to one of two control conditions. To determine whether the effect of focused attention on later food intake is influenced by meal satisfaction, in a second study, participants ($N = 147$, 100% female, BMI $M = 25.15\ kg/m^2$) were given either a satisfying or dissatisfying lunch. In both studies, after 3 h participants ate snack food ad libitum and completed assessments of their memory for the recent lunch. In both studies there was no effect of focused attention on later food intake. In Study 2, the effect of focused attention on later food intake was not moderated by meal satisfaction. In both studies focused attention did not improve memory for the lunch meal. The present studies failed to replicate the effect of focused attention on later food intake and this may be because focused attention did not improve memory for the lunchtime meal. Further research should examine the conditions under which attention during eating influences memory encoding and food intake.

1. Introduction

A body of research indicates that attention and memory can influence eating behaviour (Higgs, 2016). In animal studies, selective lesions to the hippocampus (a key brain region associated with encoding and retrieval of memories) induces altered meal patterns, overeating, and weight gain (Clifton, Vickers, & Somerville, 1998; Davidson, Kanoski, Schier, Clegg, & Benoit, 2007; Davidson, Kanoski, Walls, & Jarrard, 2005). In humans, patients with amnesia report no memory for recent eating and will eat multiple consecutive meals (Higgs, Williamson, Rotshtein, & Humphreys, 2008; Rozin, Dow, Moscovitch, & Rajaram, 1998). It is also possible to manipulate memory for recent eating in neurologically intact humans, as shown by studies in which cueing memory of an earlier meal is found to decrease subsequent food consumption (Higgs, 2002; Higgs, Williamson, & Attwood, 2008). In a laboratory study, Brunstrom and colleagues showed that memory for what was eaten was a better predictor of later hunger than what was actually eaten, and also showed that memory for recent eating does not need to be explicitly cued in order to influence subsequent food intake (Brunstrom et al., 2012).

Attention and memory interact, such that manipulating the amount of attention paid to food at the time of consumption can alter memory encoding for the eating episode (Robinson et al., 2013), in turn affecting subsequent food intake. Eating while distracted (e.g., watching TV or playing a video game) has been associated with poorer memory for the earlier eating episode, and increased hunger and food intake later the same day (Higgs & Woodward, 2009; Mittal, Stevenson, Oaten, & Miller, 2011; Oldham-Cooper, Hardman, Nicoll, Rogers, & Brunstrom, 2011). Conversely, there is initial evidence that increasing attention paid to food can enhance memory for the eating episode and reduce subsequent snack intake. Specifically, encouraging participants to pay focused attention to the sensory properties of the food whilst eating reduced later intake, both in undergraduate female students (Higgs & Donohoe, 2011) and in females with overweight/obesity

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(Robinson, Kersbergen, & Higgs, 2014). Likewise, Seguias and Tapper (2018) recently replicated the effect of focused attention reducing later snack intake in a sample of normal weight men and women.

What is not clear yet is what aspects of meal memory are responsible for the effect of focused attention on later food intake. In a study by Higgs and Donohoe (2011) memory vividness for the earlier meal was enhanced, however this was not replicated by Robinson et al. (2014) or Seguias and Tapper (2018). Episodic memories can comprise multiple elements of an event, including visual, auditory and sensory characteristics, and concurrent thoughts and feelings (Conway, 2009; Tulving, 1983). Therefore, further research is needed to identify the episodic elements responsible for the effect that focused attention has on later food intake. Understanding the specific aspects of memory underlying this effect will inform theory as to how memory for recent eating influences subsequent consumption. We hypothesised that two aspects of meal memory may be enhanced by focused attention: visual memory for the amount of food consumed (memory for portion size) and memory for the satiating effects of the meal. A key property of episodic memories is their visual nature (Conway, 2009). Mittal et al. (2011) found that participants who ate while distracted during a laboratory study remembered eating fewer items than those who ate while not distracted, indicating poorer memory for the portion size consumed. Similarly, in a laboratory study memory for the perceived portion size of soup consumed was a stronger predictor of hunger 2 and 3 h later than the actual portion size consumed (Brunstrom et al., 2012). Experienced satiety is thought to influence satiety expectations about foods (Irvine, Brunstrom, Gee, & Rogers, 2013), which in turn predicts subsequent meal size (Brunstrom & Rogers, 2009; Wilkinson et al., 2012). Further, memory for satiety expectations has been shown to influence subsequent hunger and fullness (Brunstrom, Brown, Hinton, Rogers, & Fay, 2011).

This paper reports the results of two laboratory studies that aimed to replicate the effect of focused attention on later snack intake and examine the aspects of meal memory that are responsible for why later snack intake is reduced.

2. Study 1

2.1. Overview

Study 1 examined the effect of focused attention instructions during a lunchtime meal on later snack intake, compared to two control conditions. Participants consumed a fixed lunchtime meal and returned 3 h later, where ad libitum snack intake, visual memory for the amount of food eaten at lunch and memory for the satiety providing effects of the lunchtime meal were assessed. There is variability in how well people can consciously recall interoceptive states (Ainley, Apps, Fotopoulou, & Tsakiris, 2016), and so we utilised both a direct measure of (self-reported) memory for satiety and an indirect measure that is less reliant on conscious recall (measure of expected satiety). In this study we also aimed to recruit a more representative sample than has been used in previous studies by recruiting both men and women, and a BMI range that is representative of the UK population.

2.2. Methods and materials

2.2.1. Participants

Previous studies have found a large effect of focused attention on later food intake (Higgs & Donohoe, 2011; $d = 0.88$, Robinson et al., 2014; $d = 0.73$), and so to be conservative this study was powered to detect a medium-large effect size. In order to detect a main effect of attention condition at 80% power (with gender as an additional main effect in the analysis), 37 participants per condition were required ($N = 111$). To allow for having to exclude a small number of participants from analyses (e.g., guessing aims, outliers) we recruited slightly above this number, resulting in a total of 124 participants. Inclusion criteria for the study were males and females aged 18–60 years old with a self-reported BMI 22.5–32.5 kg/m^2, who were fluent speakers of English, regular breakfast eaters, not taking medication that affects appetite, and had no food allergies or history of disordered eating. The specified BMI range was chosen as this is representative of the UK (approximately 70% of the UK population fall within this BMI range, NatCen Social Research, 2014).

2.2.2. Design

Participants were recruited to a study described as looking at the effects of mood on taste perceptions. Using a between-subjects design (the website sealedenvelope.com was used to create the allocation sequence) participants were randomly assigned to eat a fixed lunchtime meal under one of three attention conditions: (1) whilst listening to audio instructions via headphones which encouraged listeners to attend to the meal they were eating; participants were instructed to focus on and pay attention to the look, smell and flavour of the food (focused attention, FA), (2) wearing the same set of headphones but listening to an audio book unrelated to food; participants listened to a description of the migration and breeding pattern of cuckoo birds (headphone control group, HC), or (3) without headphones (normal control, NC). Both audio clips lasted 3 min. The focused attention audio clip was identical to previous studies (Higgs & Donohoe, 2011; Robinson et al., 2014). A full transcript of the focused attention audio clip is provided in the supplementary materials. Participants returned 3 h later and snack food intake and meal memory were measured. Allocation to condition was stratified by gender to ensure approximately equal numbers of males and females per condition.

2.2.3. Lunchtime meal

Lunch was a fixed portion of cooked pasta (170g) with tomato sauce (110g) (Tesco, UK) served hot on a 22.5 cm diameter white plate (~300 kcal). This was the manufacturers recommended serving size and was rated by the majority of participants as being a normal portion size in a recent study in our laboratory ($N = 60$, 50% female, BMI 22.5–32.5 kg/m^2, Haynes et al., unpublished manuscript). A glass of water was also provided (200 ml). To check compliance with the instruction to eat the entire meal, the amount of the lunch consumed was calculated as a percentage of the amount provided.

2.2.4. Bogus taste-test

The bogus taste-test is a valid measure of food intake (Robinson et al., 2017), and in this study participants were provided with two well-stocked bowls of biscuits (~114g/555 kcal Maryland chocolate chip cookies, ~148g/763 kcal of Cadbury's chocolate fingers) and were asked to rate how crunchy, flavoursome and enjoyable each biscuit type was on 100-point visual analogue scales (anchors: not at all, extremely). The biscuits were broken into bite-sized pieces to prevent participants from monitoring how many biscuits they ate. Participants were given 10 min to complete this task and were told that any remaining food at the end of the study would be thrown away. Biscuit consumption was calculated by subtracting the post taste-test weight from the pre taste-test weight. Grams consumed was converted to kilocalories and summed across biscuit types to produce the main dependent variable (total snack intake in kcal).

2.2.5. Measures

Lunch meal liking and satisfaction. Participants were asked to rate the extent to which they agreed with the following statements on 100-point visual analogue scales (anchors: not at all, extremely), 'I liked the lunchtime meal' and 'the lunchtime meal was satisfying'.

Memory Vividness. Participants were asked to 'think back to eating lunch earlier, how vivid is your memory of eating lunch?' (Higgs & Donohoe, 2011; Robinson et al., 2014) (100-point visual analogue scale, anchors: not at all, extremely).

Self-reported memory for satiety. Participants were asked to 'think back to the lunchtime meal of pasta you ate earlier … ' and rate (1) 'how filling was the lunchtime meal?', (2) 'how satisfying was the lunchtime meal?', (3) 'how full up did you feel after the lunchtime meal?' and (4) 'how satisfied did you feel after the lunchtime meal?' on 100-point visual analogue scales (anchors: not at all, extremely).

Expected satiety (indirect measure). Participants completed a computerised task in which they were asked to select the portion size of 18 meal foods to indicate the amount of food that would be required to produce the sensation of fullness that they experienced after lunch; adapted version of (Brunstrom, Shakeshaft, & Scott-Samuel, 2008). Food pictures started at 20 kcal and increased in 20 kcal increments up 1000 kcal. The outcome measure for the expected satiety task was the average kcal of the portion sizes selected.

Visual memory for portion size. Participants were presented with a large bowl of four times the amount of the same pasta and sauce they were served at lunch (680g cooked cold pasta and 440g sauce), the same plate the lunchtime meal was served on and a large serving spoon. Participants were asked to self-serve the amount of pasta they ate at lunch, as in Brunstrom et al. (2012). An accuracy score was calculated by taking the absolute value of the difference between the amount of pasta self-served and the amount actually consumed at lunch (converted to kcal).

English language picture recall test. As an informal check that participants could speak English sufficiently to complete the study, participants were asked to write down the names of 18 non-food objects at the beginning of the first study session. To examine whether any effects on memory performance were food specific, participants were asked to recall as many of these non-food objects as possible in the second session.

Other measures. In order to characterise our sample we included measures of age and dietary habits (Three Factor Eating Questionnaire-R21; TFEQ, Cappelleri et al., 2009). Participants also completed the same computerised task as used to measure expected satiety but were asked to adjust the portion size for each meal item to reflect their ideal portion size for lunch (with the average kcal of the 18 foods as the outcome measure). This was done to check that groups did not differ in their ideal portion sizes of the foods. Participants also answered whether they had eaten the 18 foods in this task before to check familiarity with the foods (familiarity task).

2.2.6. Procedure

Participants were asked to eat their usual breakfast on the day of participation and to abstain from eating 2 h prior to the lunchtime session. After being screened for eligibility over email, participants attended a lunchtime session where they first completed a medical history questionnaire to ensure they did not have any food allergies, and the English language test. Participants then completed the ideal portion-size task and the familiarity task. Next they completed a set of 100-point visual analogue scales (anchors: 'not at all' to 'extremely') to measure hunger, fullness (e.g. 'how hungry do you feel right now?') and various mood dimensions to bolster the cover story. The researcher then brought in the pasta lunch and a glass of water. Participants were instructed to listen carefully to the audio clip whilst eating (for the focused attention and headphone control condition) and told that they should try to finish all of the meal. Participants were asked to let the researcher know when they had finished eating and meal duration was timed. After alerting the researcher that they had finished, participants were asked to complete the questions on liking and satisfaction with the lunchtime meal, then the appetite and mood rating scales, and then a short filler questionnaire. Participants were then asked to not eat and to only drink water between sessions.

When returning for the second session 3 h from the start of their first session participants completed the same appetite and mood rating scales as in the first session. Next, participants completed the taste-test. Participants then completed the appetite and mood rating scales again. The memory measures were then completed, starting with the memory vividness measure, followed by the visual memory for portion size and memory for satiety measures in a randomised order. Within the memory for satiety measures, participants completed the self-report measure first and then the expected satiety task. Participants were then given 3 min to recall as many objects as possible from the English language picture test. Finally, participants completed the TFEQ, demographic questions, recorded the last time they ate before the first study session and whether they ate between study sessions (to check compliance). Awareness of the study aims was assessed using a funnelled debrief procedure where participants were asked to write down (1) 'what do you think the aims of the study were?', (2) 'what do you think we were expecting to find?' and (3) 'based on how you ate lunch in the first session, how do you think we expected this to affect your behaviour?' Height and weight were then measured using a stadiometer and electronic scales (heavy clothing and shoes removed) in order to calculate BMI, before participants were debriefed and reimbursed.

2.2.7. Analysis strategy

One-way ANOVAs were used to check for baseline group differences on demographic variables, percentage of the lunch eaten, ideal portion size and hunger across the study. The items measuring self-reported memory for satiety were correlated (smallest $r = 0.62$) and loaded onto a single factor (Cronbach's alpha = 0.91). Therefore, these questions were averaged to form a single measure. For our primary analyses, snack intake and memory measures were analysed with 2 (gender: male, female) x 3 (attention condition: focused attention, normal control, headphone control) ANOVAs. We included gender as a factor in the analysis as males tend to eat more than females in laboratory settings (Robinson et al., 2017). Partial eta squared was reported as our measure of effect size (Cohen, 1988; small = 0.01; medium = 0.06; large = 0.14). For the expected satiety and ideal portion size tasks if any food was familiar to less than 50% of participants, that meal item was excluded from the outcome measure for these tasks. One meal food was familiar to only 41.7% of participants (grilled fish dish) so this item was excluded, leaving 17 meal items remaining in the expected satiety and ideal portion size tasks.

2.3. Results

2.3.1. Sample

Out of the 124 participants that completed the study, 16 were excluded from the main analyses: 7 because they did not comply with the study instructions (e.g. ate in between the study sessions or did not attend the second session), 1 because their actual measured BMI was far out of the targeted eligibility range (39.81 kg/m^2), 4 because they ate less than 75% of the lunch, 1 due to missing data on snack intake and 3 because their snack intake was 2.5 SDs higher than the sample mean. The final analysed sample size was 108 (52.8% female; focused attention n = 34; normal control n = 37, headphone control n = 37). Mean BMI (measured weight kg/measured height m^2) on the day of testing was 25.75 kg/m^2 (SD = 3.37). There were no significant differences between groups on measured characteristics and groups did not differ in hunger across study time-points (see Table 1).

2.3.2. Ad libitum snack intake

There was a significant main effect of gender, $F(1,102) = 8.06$, $p = 0.01$, $\eta^2 = 0.07$, such that males consumed more snack food than females (males M = 422.21 kcal, SD = 224.79; females M = 312.72 kcal, SD = 162.86). Contrary to the hypotheses, there was no significant main effect of attention condition, $F(2,102) = 0.13$, $p = 0.88$, $\eta^2 = 0.003$. There was also a non-significant interaction between gender and attention condition, $F(2,102) = 1.54$, $p = 0.22$, $\eta^2 = 0.03$. See Fig. 1.

2.3.3. Memory measures

There was a significant main effect of gender on self-reported

Table 1
Sample characteristics as a function of attention condition.

	Normal Control mean (*SD*) n = 37	Headphone Control mean (*SD*) n = 37	Focused Attention mean (*SD*) n = 34	F (η^2)
BMI (kg/m^2)	26.02 (3.21)	25.27 (2.94)	25.97 (3.98)	0.55 (0.01)
Age (y)	27.57 (11.99)	29.16 (10.63)	29.91 (10.50)	0.42 (0.01)
Cognitive restraint	2.23 (0.42)	2.45 (0.50)	2.34 (0.49)	2.15 (0.04)
Uncontrolled eating	2.56 (0.61)	3.31 (0.51)	2.44 (0.47)	2.16 (0.04)
Emotional eating	2.25 (0.78)	1.89 (0.64)	2.19 (0.79)	2.46 (0.05)
Ideal portion size (kcal)	515.33 (145.28)	435.36 (153.61)	466.38 (174.82)[a]	2.42 (0.04)
Percentage of lunch consumed	97.02 (2.33)	95.94 (4.26)	96.82 (4.65)	0.82 (0.02)
Pre-lunch hunger	62.08 (22.49)	64.35 (21.32)	69.35 (19.71)	1.08 (0.02)
Post-lunch hunger	15.11 (13.26)	19.70 (19.27)	15.74 (14.55)	0.90 (0.02)
Pre-ad libitum snack hunger	49.19 (22.02)[a]	48.43 (26.61)	41.21 (25.08)	1.11 (0.02)
Post-ad libitum snack hunger	22.81 (21.29)[a]	22.27 (21.34)	16.85 (18.90)	0.89 (0.02)

Note. *$p < 0.05$; [a] = data missing for 1 participant. Range of possible scores: cognitive restraint, uncontrolled eating, emotional eating = 1–4; ideal portion size = 20–1000 kcal; all hunger variables = 1–100.

memory for satiety, such that males remembered the lunch to be less satiating than females (100-point scale, males M = 52.55, SD = 21.93; females M = 63.06, SD = 22.34). There were no other significant effects of gender, attention condition or of the interaction between gender and attention condition for any memory measure, see Table 2. Ab libitum snack intake did not significantly correlate with any memory measures (see Study 1 correlations section of supplementary materials).

2.3.4. Sensitivity analyses

Two researchers independently coded participants as having guessed the aims of the study if they believed that how they ate lunch would affect how much snack food they ate. Any disagreements were resolved by discussion. Three participants guessed the study aims. However, excluding these participants had no effect on the results for snack intake.

2.3.5. Exploratory analyses

One-way ANOVAs with attention condition as the factor were used to explore group differences that could potentially explain the unexpected null results. There was a significant effect of attention condition on participants' reports of how satisfying and well liked the lunchtime meal was when rated immediately after consumption. LSD post-hoc comparisons showed that the focused attention group found the lunchtime meal significantly less satisfying and liked it less than the normal control group (see Table 3). There was also a significant effect of attention condition on meal duration and eating rate (calculated as grams of pasta consumed per minute). LSD post-hoc tests showed that those in the focused attention group spent significantly longer eating and showed a slower eating rate than the normal and headphone

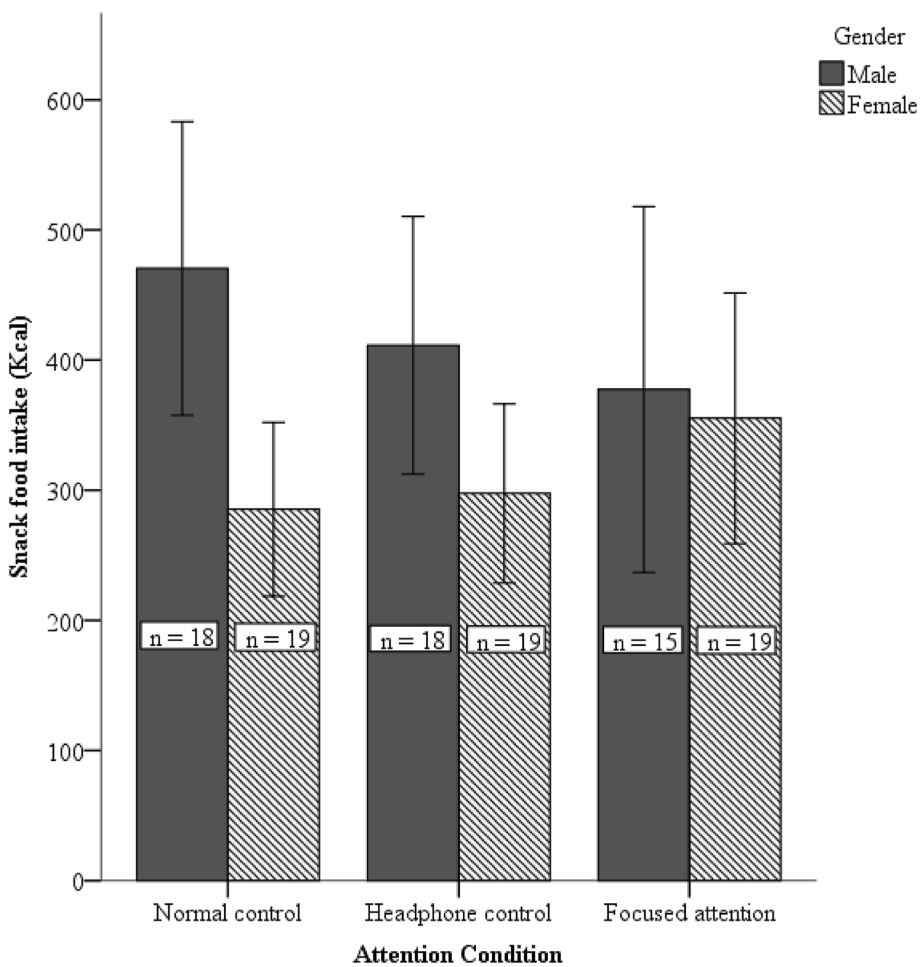

Fig. 1. Snack food intake as a function of attention condition and gender (error bars represent 95% CIs).

Table 2
Memory measures as a function of attention condition.

	Normal control (*SD*) n = 37		Headphone control (*SD*) n = 37		Focused attention (*SD*) n = 34		Gender *F* (η^2)	Attention Condition *F* (η^2)	Gender x Attention Condition *F* (η^2)
	Male n = 18	Female n = 19	Male n = 18	Female n = 19	Male n = 15	Female n = 19			
Self-reported memory for satiety (100-point scale)	53.90 (22.79)	68.28 (17.28)	54.53 (22.38)	60.12 (27.97)	48.57 (21.32)	60.79 (20.34)	6.22* (0.06)	0.74 (0.01)	0.39 (0.01)
Expected satiety (kcal)	418.50 (114.79)	367.86 (108.52)	395.50 [a] (137.48)	345.08 (92.56)	395.92 (140.61)	382.91 (111.04)	2.79 (0.03)	0.39 (0.01)	0.29 (0.01)
Memory for portion size accuracy (kcal) ~	34.71 (28.77)	44.39 [a] (35.11)	39.45 (23.35)	46.46 (33.79)	44.39 [a] (41.67)	39.39 (34.14)	0.37 (0.004)	0.10 (0.002)	0.47 (0.01)
Memory vividness (100-point scale)	81.33 (13.15)	72.37 (31.97)	69.22 (23.29)	76.68 (19.45)	79.13 (24.49)	75.89 (15.70)	0.14 (0.001)	0.45 (0.01)	1.30 (0.03)
Memory for non-food objects†	7.61 (2.03)	7.26 (1.85)	7.78 (2.51)	7.00 (1.63)	7.00 (2.10)	7.63 (1.83)	0.18 (0.002)	0.03 (0.001)	1.13 (0.02)

Note. *$p < 0.05$; [a] = data missing for 1 participant.
~ group mean of the absolute difference between memory for portion size and actual consumed portion size, 0 kcal = perfect recall.
†number of items recalled out of 18.

control groups (both *p*'s < 0.001).

2.4. Discussion

Unlike in previous studies (Higgs & Donohoe, 2011; Robinson et al., 2014; Seguias & Tapper, 2018) focused attention during lunch did not reduce snack intake 3 h later. We also found no evidence that focused attention affected meal memory. However, unexpectedly the focused attention group found the lunchtime meal less satisfying and liked the meal less than the normal control group. The 300 kcal served for lunch in the present study was less energy than in other studies (approximately 400–550 kcal: Higgs & Donohoe, 2011; Robinson et al., 2014), and this may have contributed to the lunchtime meal being less satisfying and less well liked, which was then exacerbated by the focused attention manipulation. We therefore reasoned that our failure to replicate the effect of focused attention on later snack food intake may be explained by focused attention only reducing later food intake when a meal has been satisfying. In other words, when a meal is relatively satisfying, focused attention later results in participants remembering it as so and their subsequent food intake is reduced. This may have been the case in Higgs and Donohoe (2011), Robinson et al. (2014) and Seguias and Tapper (2018). However, when a meal is not satisfying (due to a small portion size or unenjoyable consumption experience), focused attention may have no beneficial effect on later intake, which may have been the case in Study 1. We tested this hypothesis in Study 2.

3. Study 2

3.1. Overview

Study 2 investigated whether the effect that focused attention during a meal has on later snack intake is dependent on how satisfying the earlier meal was. We hypothesised that focused attention would decrease later food intake when the initial meal was satisfying, but would have no effect when the initial meal was less satisfying. Further, memory for the amount of food eaten at lunch and the satiety providing effects of the lunchtime meal were assessed. The general methods for Study 2 were similar to those described for Study 1 and so only variations in the methods are described. To be comparable with studies that had shown an effect of focused attention on later snack food intake we recruited females only in Study 2. The method and analysis strategy for Study 2 was pre-registered on the Open Science Framework (see protocol here: osf.io/t3ssn).

3.2. Methods and materials

3.2.1. Participants

As the interactive effect of meal satisfaction and focused attention manipulation on later food intake has not been tested before the potential effect size was not known. We deemed that powering the study to detect a medium sized interaction effect was therefore reasonable ($f = 0.25$). In order to detect a medium-size interaction with 80% power required a minimum sample size of 128 participants (n = 32 per cell). To allow for having to exclude a small number of participants from analyses we recruited 40 per cell (N = 160). Only females with English as their first language were recruited for Study 2, all other inclusion criteria were the same as Study 1.

3.2.2. Design

The cover story was the same as in Study 1. Using a between-subjects design participants were randomly assigned (same method as Study 1) to consume a standard size (satisfying) or a small (dissatisfying) lunch, under either focused attention or a control condition in which participants ate lunch normally (normal control). This created four experimental cells: focused attention/satisfying meal-type (FA/S), focused attention/dissatisfying meal-type (FA/D), normal control/satisfying meal-type (NC/S), and normal control/dissatisfying meal-type (NC/D). Participants returned 3 h later for a bogus taste-test and other measures.

Table 3
Lunch liking, meal duration and eating rate as a function of attention condition.

	Normal Control (SD) n = 37	Headphone Control (SD) n = 37	Focused Attention (SD) n = 34	*F* (η^2)
Lunch liking (100-point scale)	64.05 (28.48)	56.59 (19.34)	48.62 (26.57)	3.36* (0.06)
Lunch satisfaction (100-point scale)	67.46 (25.83)	61.24 (19.87)	52.00 (25.47)	3.76* (0.07)
Meal duration (minutes)	5.16 (2.04) [a]	6.14 (2.17)[b]	12.97 (3.26)[b]	91.80** (0.65)
Eating rate (g/m)	58.72 (22.37)[a]	49.09 (22.17)[b]	21.60 (5.86) [b]	33.98** (0.41)

Note. *$p < 0.05$, **$p < 0.001$; [a] = data missing for 2 participants; [b] = data missing for 3 participants.

Table 4
Sample characteristics as a function of attention condition and meal-type.

	FA/S (SD) n = 34	FA/D (SD) n = 36	NC/S (SD) n = 39	NC/D (SD) n = 38	Attention Condition F (η^2)	Meal-type F (η^2)	AC x M F (η^2)
BMI (kg/m^2)	25.27 (2.74)	25.24 (2.94)	25.33 (3.03)	24.90 (2.54)	0.08 (0.001)	0.25 (0.002)	0.19 (0.001)
Age (y)	33.47 (14.12)	35.22 (14.06)	34.15 (11.85)	30.74 (11.14)	0.81 (0.01)	0.16 (0.001)	1.49 (0.01)
Cognitive restraint	2.51 (0.54)	2.40 (0.53)	2.42 (0.48)	2.27 (0.61)	1.48 (0.01)	2.01 (0.01)	0.04 (< 0.001)
Uncontrolled eating	2.44 (0.55)	2.42 (0.49)	2.62 (0.65)	2.43 (0.61)	0.94 (0.01)	1.27 (0.01)	0.81 (0.01)
Emotional eating	2.50 (0.69)	2.20 (0.75)	2.35 (0.75)	2.45 (0.83)	0.16 (0.001)	0.58 (0.004)	2.52 (0.02)
Percentage of lunch consumed	98.71 (3.68)	99.38 (3.73)	97.71 (6.35)	100 (0.00)	0.08 (0.001)	4.64* (0.03)	1.39 (0.01)

Note. *$p < 0.05$; **$p < 0.001$. Range of possible scores for cognitive restraint, uncontrolled eating and emotional eating = 1–4; AC x M = Attention Condition x Meal-type interaction.

3.2.3. Lunchtime meal

As the focused attention manipulation resulted in participants finding the lunchtime meal (a pasta dish served warm) in Study 1 less satisfying and liked, we altered the lunchtime meal for Study 2 so that the temperature of the food eaten would be constant across conditions. Participants in the satisfying meal-type condition were given a whole ham sandwich (crusts removed and cut into squares), 4 mini cheese and onion rolls and 10 original flavour Pringles (~544 kcal). This was calculated to be similar to the energy content of the lunch meal used in previous studies (Higgs & Donohoe, 2011; Robinson et al., 2014, approximately 400–500 kcal). Those in the dissatisfying meal-type condition were given exactly half of this (~272 kcal). Vegetarian participants were given an egg and salad cream sandwich instead of the ham sandwich (~600 kcal in the satisfying conditions and ~300 kcal in the dissatisfying conditions). A glass of water was also provided (200 ml).

3.2.4. Bogus taste-test

The taste-test consisted of three bowls of biscuits broken into bite-sized pieces (3 × 70g each of Maryland chocolate chip cookies ~ 341 kcal, Cadbury's chocolate fingers ~ 361 kcal and McVities digestives ~ 337 kcal; total ~ 1039 kcal), and the same rating scales as in Study 1 for each biscuit type. Smaller portions were provided in Study 2 so that the amount of food served in the taste-test was similar to that used in previous studies (Higgs & Donohoe, 2011; Robinson et al., 2014).

3.2.5. Measures

In addition to rating how much they liked the lunchtime meal and how satisfying they found it as in Study 1, as a manipulation check for level of meal satisfaction participants also rated the extent to which they agreed with the following statements 'I was dissatisfied with the lunchtime meal' and 'the size of the lunchtime meal was too small' on 100-point visual analogue scales (anchors: not at all, extremely). Self-reported memory for satiety included two questions in addition to those asked in Study 1; 'how dissatisfying was the lunchtime meal?' and 'how dissatisfied did you feel after the lunchtime meal?' (100-point visual analogue scales, anchors: not at all, extremely). Visual memory for portion size was assessed by asking participants to recall how many sandwich squares, cheese and onion rolls and Pringles they ate. To keep the length of the testing sessions manageable, participants did not complete the ideal portion size task in Study 2.

3.2.6. Procedure

The study procedure was the same as Study 1, except that the filler questions were not used in Study 2.

3.2.7. Analysis strategy

Differences across groups on demographic variables and percentage of the lunch consumed were checked with 2 (lunch meal-type: satisfying vs dissatisfying) x 2 (attention condition: focused attention vs normal control group) ANOVAs. The three post-lunch meal satisfaction questions were correlated (smallest $r = 0.46$) and all items loaded onto a single factor[1] (Cronbach's alpha = 0.73). Therefore, the mean of these items was calculated to create a single outcome measure. We also used 2x2 ANOVAs to check whether our manipulation was successful (with meal satisfaction immediately post-lunch as the outcome) and to compare conditions on the main outcome measure (total snack intake in kcals). We examined the effect of attention and meal-type conditions (between-subject factors) on hunger across study time-points (repeated measures factor; baseline, post lunch, pre snack, post snack) using mixed ANOVA. The self-reported memory for satiety questions were correlated (smallest $r = 0.48$) and principle components analysis showed that all items loaded onto a single factor (Cronbach's alpha = 0.93). Therefore, these questions were averaged to form a single measure. Separate 2 x 2 ANOVAs were conducted for all memory measures, as they did not correlate sufficiently to justify using MANOVA (as was the plan in the pre-registered protocol). In the expected satiety task one meal item was familiar to only 42.5% of participants (grilled fish dish) so this item was excluded, leaving 17 meal items remaining.

3.3. Results

3.3.1. Sample

Thirteen participants were excluded from the analyses: 7 because they did not comply with study instructions, 1 because snack intake was more than 2.5 SD from the sample mean, 2 because actual BMI was more than 2 points outside of the criteria and 3 because they ate less than 75% of the lunch. The final analysed sample was 147 (NC/D = 38, NC/S = 39, FA/D = 36, FA/S = 34). Mean BMI (measured weight kg/measured height m^2) on the day of testing for the final sample was 25.18 kg/m^2 (SD = 2.80). There were no significant differences between groups on measured characteristics (Table 4). There was a significant difference between the two meal-types in percentage of the lunch consumed, such that the dissatisfying meal-type groups ate slightly more of the lunch than the satisfying meal-type groups (dissatisfying M = 99.70%, SD = 2.60% satisfying M = 98.18%, SD = 5.27%), although this difference was small. At lunch the groups ate: NC/D M = 240.72 kcal, SD = 12.30; NC/S M = 461.42 kcal, SD = 37.74; FA/D M = 240.52 kcal; SD = 16.88; FA/S M = 462.49 kcal, SD = 28.38.

3.3.2. Hunger

Groups did not differ on hunger at baseline. Hunger decreased more in those who received the satisfying compared to dissatisfying meal-type from pre-lunch to post-lunch, whereas hunger increased more in the dissatisfying compared to satisfying meal-type from post-lunch to pre-ad libitum snack and decreased more from pre ad libitum to post ad libitum snack. See supplementary materials Study 2 hunger section for full statistical information.

[1] The use of principle components analysis to examine factor loading (as in Study 1) was not stated in the pre-registered protocol for Study 2 in error.

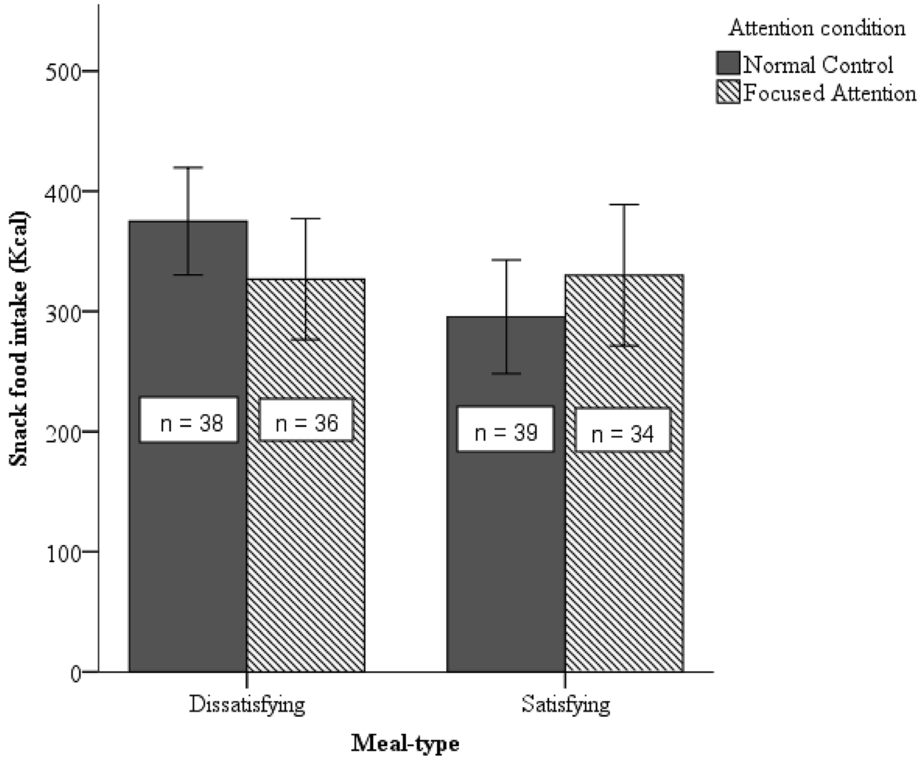

Fig. 2. Ad libitum snack intake as a function of meal-type and attention condition (error bars represent 95% CIs).

Table 5
Memory measures as a function of attention condition and meal-type.

	FA/S (SD) n = 34	FA/D (SD) n = 36	NC/S (SD) n = 39	NC/D (SD) n = 38	Attention Condition F (η^2)	Meal-type F (η^2)	AC x M F (η^2)
Self-reported memory for satiety (100-point scale)	64.55 (22.43)	49.02 (23.14)	65.72 (23.56)	43.23 (18.25)	0.41 (0.003)	27.55** (0.16)	0.92 (0.01)
Expected satiety (kcal)	315.12 (81.63)	214.53 (94.59)[b]	330.83 (125.30)	256.34 (133.29)[b]	2.36 (0.02)	21.90** (0.14)	0.49 (0.003)
Memory for portion size accuracy (number of items)~	3.09 (2.20)[a]	0.81 (0.75)	3.64 (3.86)	0.84 (0.97)	0.56 (0.004)	42.92** (0.23)	0.45 (0.003)
Memory vividness (100-point scale)	79.85 (12.82)	75.89 (20.52)	73.67 (28.93)	78.50 (16.90)	0.27 (0.002)	0.02 (0.001)	1.62 (0.01)
Memory for non-food objects †	7.50 (1.88)	7.44 (1.98)	7.13 (1.78)	7.39 (2.16)	0.43 (0.003)	0.12 (0.001)	0.25 (0.002)

Note. $^*p < 0.05$, $^{**}p < 0.001$; [a] = data missing for 1 participants; [b] = data missing for 2 participants; AC x M = Attention Condition x Meal-type interaction.
~ group mean of the absolute difference between memory for portion size and actual consumed portion size, 0 = perfect recall.
† number of items recalled out of 18.

3.3.3. Manipulation check

ANOVA showed a significant main effect of meal-type on meal satisfaction immediately after lunch, $F(1,143) = 13.10$, $p < 0.001$, $\eta^2 = 0.08$, indicating that those who received the dissatisfying lunch found the lunch less satisfying than those who received the satisfying lunch (100-point scale, dissatisfying meal $M = 61.05$, $SD = 20.48$; satisfying meal $M = 73.52$, $SD = 20.97$). There was no significant main effect of attention condition, $F(1,143) = 0.42$, $p = 0.52$, $\eta^2 = 0.003$, and the interaction between attention condition and meal-type was non-significant, $F(1,143) = 0.14$, $p = 0.71$, $\eta^2 = 0.001$.

3.3.4. Ad libitum snack intake

There was no significant main effect of attention condition, $F(1,143) = 0.07$, $p = 0.79$, $\eta^2 = 0.001$, or meal-type, $F(1,143) = 2.37$, $p = 0.13$, $\eta^2 = 0.02$, and the interaction between attention condition and meal-type was also non-significant, $F(1,143) = 2.79$, $p = 0.10$, $\eta^2 = 0.02$. See Fig. 2.

3.3.5. Memory measures

There was a significant main effect of meal-type on both self-reported memory for satiety and expected satiety (see Table 5), such that those who received the dissatisfying lunch remembered the lunch to be less satiating than those who received the satisfying lunch on both tasks (self-reported memory for satiety, 100-point scale: dissatisfying lunch $M = 46.04$, $SD = 20.83$, satisfying lunch $M = 65.17$, $SD = 22.89$; expected satiety: dissatisfying lunch $M = 236.03$ kcal, $SD = 117.19$, satisfying lunch $M = 323.51$ kcal, $SD = 106.78$). The main effect of attention condition and the effect of the interaction between attention condition and meal-type were non-significant for both self-reported memory for satiety and expected satiety. For memory for portion size, there was a significant main effect of meal-type, such that the dissatisfying lunch group remembered the number of items eaten for lunch more accurately than the satisfying lunch group (dissatisfying lunch $M = 0.83$, $SD = 0.87$, satisfying lunch $M = 3.39$, $SD = 3.20$). A score closer to zero indicates better memory for the number of items eaten. The results were the same when memory for portion size was converted to kcal, see supplementary materials Study 2 visual memory for portion size section. There was no significant main effect of attention condition and the interaction between attention condition and meal-type was non-significant. There were no significant effects for memory vividness or the number of non-food objects recalled, see Table 5.

3.3.6. Sensitivity analyses

Excluding participants that did not eat all of the lunch (n = 11) had no effect on the pattern of results and estimate of effect size for the hypothesised interaction between attention condition and meal-type on ad libitum snack intake. Two researchers independently coded participants' as having guessed the study aims if they mentioned that they expected how they ate lunch would affect how many biscuits they ate in the second session and whether the size of lunchtime meal would influence this. Two participants guessed that focusing attention on lunch would affect later food intake. Removing these participants had no effect on the hypothesised interaction for snack intake. Excluding additional participants with values more than 2.5 SD from the mean on memory measures (expected satiety n = 4, memory for portion size n = 2, memory vividness n = 3 and number of non-food objects recalled n = 2) also made no difference to the pattern of results.

3.3.7. Exploratory analyses

Groups did not differ in liking for the lunchtime meal. Focused attention groups showed a longer meal duration and slower eating rate than the normal control groups in those who received the satisfying and dissatisfying meal-types. See supplementary materials Study 2 exploratory analyses section for full details). Snack food intake did not correlate with any memory measures (see supplementary materials Study 2 correlations section).

4. General discussion

In two studies we found no evidence that focusing attention on food during a lunchtime meal affected snack intake 3 h later. We also found that memory for the lunchtime meal was not enhanced by focused attention. Study 2 also showed that focused attention did not influence later snack intake, regardless of how satisfying the earlier meal was. This is in contrast to three other studies that have shown that focused attention during a lunchtime meal decreased snack food intake two to 3 h later (Higgs & Donohoe, 2011; Robinson et al., 2014; Seguias & Tapper, 2018). The results from the current studies suggest that the effect of focused attention on later snack intake is not as robust as previous studies suggest.

One explanation for finding no difference in later snack food intake between focused attention and control conditions in the present studies is that focused attention did not enhance memory for the lunchtime meal. One theory of why focused attention decreases later food intake is that greater attention to food during an eating episode enhances memory encoding of the meal. It follows that if meal memory is not enhanced by focused attention, then subsequent food intake will not be affected. Enhancing memory for a meal may be more difficult than impairing memory and this may explain why focused attention does not consistently affect later food intake. Several studies have shown that distraction impairs memory for a meal and promotes increased subsequent food intake (Higgs & Woodward, 2009; Higgs, 2015; Mittal et al., 2011; Oldham-Cooper et al., 2011). These findings are consistent across different measures of meal memory, including memory vividness for the earlier meal, memory for the quantity of food/drinks consumed and the order in which lunch items were consumed when eaten one at a time. One potential reason why memory for lunchtime food intake was not enhanced by focused attention is that listening to the audio instructions whilst listening could have been annoying or uncomfortable for some participants and caused reactance (Martin & Achee, 1992). While participants spent longer eating and ate at a slower rate, reactance to the manipulation may have interfered with natural processes of attending to the meal and memory formation.

In studies of focused attention, ceiling effects may also be a limiting factor. Memory vividness was high in the control conditions in the studies reported here and others (Robinson et al., 2014), and when asked to recall aspects of the earlier meal, participants were generally very accurate in remembering the portion size consumed and how full they felt after the meal (Study 1 and 2 reported here, Seguias & Tapper, 2018). This may indicate that the setting or procedures resulted in participants in the control conditions closely attending to the food they were eating. Future research may be more successful at enhancing meal memory in eating contexts in which consumers are not likely to be attending to their meal.

A secondary aim of the present studies was to identify elements of episodic memory that govern the effect of focused attention on later intake. Although our failure to find evidence for the effect of focused attention on memory or later food intake prevented us from achieving this objective, a recently published study (Seguias & Tapper, 2018) found that participants who focused their attention on a lunchtime meal subsequently ate less snack food, but did not later recall how satiated they felt after lunch or how much food they ate any more accurately than the control group. As previous studies had tended to recruit female participants, we recruited men and women in Study 1, although we did not find evidence that gender moderated the effect of focused attention on later food intake. Seguias and Tapper (2018) found reduced snack intake following focused attention to a meal regardless of participant gender, albeit with a relatively small number of male participants, as was the case in Study 1 here.

4.1. Strengths and limitations

Strengths of the present studies were the use of larger sample sizes for the main effect of attention condition compared to previous comparable studies (Higgs & Donohoe, 2011; Robinson et al., 2014; Seguias & Tapper, 2018) and the decision to recruit a more representative sample of participants (e.g., BMI, gender). A further strength of the present studies was that the memory measures were sensitive to the difference in amounts consumed in the satisfying and dissatisfying conditions in Study 2, which validates their use as sensitive measure of memory for a previous dietary experience.

A limitation of the present studies and of previous studies (Higgs & Donohoe, 2011; Robinson et al., 2014; Seguias & Tapper, 2018) is that we did not include a direct measure of whether participants followed the focused attention instructions. However, in both present studies participants in the focused attention condition spent longer eating and ate at a slower rate during the lunchtime meal than controls, indicating that participants were likely to be following the focused attention instructions. Despite this, eating rate may not be the most reliable measure as it is not clear whether participants did indeed let the researcher know as soon as they had finished eating. A further limitation was that the number of male and female participants per experimental condition in Study 1 was low (Ns < 20), so Study 1 was not powered to detect whether gender moderates the effect of focused attention. Further work designed to examine the effect of focused attention in males would now be valuable. In the present studies later snack food consumption was higher than in studies with predominantly normal weight samples (Higgs & Donohoe, 2011; Seguias & Tapper, 2018). However, later snack intake was comparable to the amount of snack food consumed by women with overweight/obesity in a previous study that did show an effect of focused attention on later snack food intake (Robinson et al., 2014). Future work could also examine whether focused attention affects other aspects of memory for the meal. The energy needs of participants could also be better controlled in subsequent studies, such as by providing meals that are tailored to each individuals' energy requirements to ensure the food is sufficient (instead of using a fixed lunch as in the present and previous studies; Higgs & Donohoe, 2011; Robinson et al., 2014) and restricting what participants can do in between study sessions (e.g. physical activity). It is possible in the current studies that later food intake influenced how participants then reported their memory for the earlier lunch (e.g. reported it to be less satiating if they ate a lot of biscuits). Counterbalancing the order in which meal memory and later food intake are measured in future work would go some way to minimising these effects.

Focused attention studies have used methods that instruct participants to attend to the sensory properties of food (Higgs & Donohoe, 2011; Robinson et al., 2014; Seguias & Tapper, 2018). While attending to the sensory properties of a meal may be sufficient to enhance memory vividness as found in Higgs and Donohoe (2011) it may not be sufficient to enhance memory for the satiating effects of the meal or the portion size of food consumed. There may be merit in future studies focusing participants' attention on the satiating properties of the meal being consumed and the amount of food eaten, as we hypothesise that these elements of meal memory may guide later eating behaviour. However, two studies have found reduced snack intake following focusing attention to an earlier meal in the absence of enhanced memory for the meal (Robinson et al., 2014; Seguias & Tapper, 2018). Thus, future research should examine mechanisms other than enhanced memory that may explain when and why focused attention can affect later food intake (for a detailed discussion see Tapper, 2017).

4.2. Conclusions

The present laboratory experiments failed to replicate the effect of focused attention on later snack food intake and this may be because focused attention did not improve memory for the lunchtime meal. Further research may benefit from understanding the conditions under which attention influences memory encoding and food intake.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.appet.2018.06.002. The data sets for Study 1 and Study 2 are accessible at osf.io/t3ssn

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